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Stimulating Innovation in Inland Waterway Navigation – The 'Ecorace-Challenge' Project

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Abstract

The use of and the business around Inland Waterway Navigation (IWN) in Flanders are often assumed to be non-sustainable and outdated. However, after taking a more profound look, this assumption appears to be not correct. IWN has better scores in terms of environmental friendliness and sustainability. In addition there is still sufficient spare capacity compared to other transport modes. However, by developing more energy efficient and/or alternative drivetrains, improvements can still be made in terms of CO2, NOx, and especially PM, the traditional weaknesses of IWN. Therefore, and in order to promote IWN, the student-competition named 'Ecorace-Challenge', was developed. The aim of this competition is to stimulate technical innovation in this sector, and to make students aware of the opportunities IWN offers. As such, a competition for universities and university colleges in close collaboration with industry was devised with the aim to improve the interaction between young engineers and this interesting sector and to let them help shaping the future of IWN. Within the competition, each student team has to build its own vessel with a sustainable drivetrain. In addition, they need to make a business plan and a FMEA. As such, the student teams act as real ship builders, trying to sell their creative and innovative ideas to investors. In this paper, the full concept of the 'Ecorace-Challenge' competition, as well as how it contributes to future innovative developments in IWN, is described.

Keywords: Ecorace-Challenge, Engineering Education, Inland Waterway Navigation, Innovation, Sustainability.

1. Introduction

The transport industry is the backbone of the European economy. It accounts for about 7% of the GDP and more than 5% of total employment in the EU can be retrieved in land transport (road, rail, inland waterways and pipelines), sea transport and air transport (European Commission, 2009). Hence, the biggest challenge in this increasing globalized, complex and demanding world is to create sustainability and environmental friendliness in this transport sector. Various problems pop up like environmental effects, continuing urbanization of Europe's population, stringent emission regulations, projected increase in both passenger and freight traffic in the coming years, the depletion of energy resources, etc. (Bhoomkar and Ceuppens, 2013). Europe's logistic sector has to evolve to a more resource efficient economy and more R&D and innovation (in alternative fuels, green vehicles, noise reduction, etc.) is necessary to create sustainability in the transport and logistics sector.

The European inland waterway network contains more than 42.000 km of rivers and canals and is very important in especially 4 countries: Germany, The Netherlands, France and Belgium. Flanders in Belgium has one of the most dense networks in the world. Rivers and canals extend for 1375 km, of which 1076 km are used for professional navigation. Moreover, according to recent studies, there is a considerable reserve capacity on the waterways, which is not the case for road and railway transport. Despite the opportunities inland waterway transport offers, it still struggles with some contemporary issues to obtain a modal shift. It has

a dated infrastructure, polluting vessels, as well as an outdated image. Improvements in terms of environmental friendliness and sustainability are essential for inland waterway transport, especially concerning the emissions of particulate matter and nitric oxide. Nevertheless, Flanders takes actions to stimulate and encourage people and industry to reinvent the waterways in a sustainable way and tries to demonstrate its environmentally friendly aspects in the logistics and transportation sector. This is done by launching several initiatives where organizations work together on different aspects of inland navigation. An example of these initiatives is 'Water-Truck', where the aim is to further develop and optimize cargo transport using small inland waterways by introducing a new navigational concept, consisting of a pusher and adapted pushed barges.

Figure 1: Inland waterway navigation in Belgium

Also in the field of education, Flanders is stimulating awareness about inland waterways. KU Leuven - GROUP T and Waterwegen en Zeekanaal NV, one of the two administrators of the Flemish waterways, have developed a boat competition for technical students focusing on inland waterways. In the 'Ecorace-Challenge' teams of technical students from different universities are being challenged to build a 6 meter long vessel, which represents a scale model of a typical inland waterway vessel. The primary focus is on developing an alternative drivetrain which propels the vessel more efficient and sustainable than current practices. During the design phase, they need to take into account strict regulations which are imposed by the organization of the competition. An important objective of the 'Ecorace-Challenge' is to bring students and maritime industry closer together. Therefore, during the year prior to the race, the teams are invited to attend several seminars where they will be introduced to the sector and its companies. Within these seminars students will gain insight in how navigable waterways can be complementary to road or railway transport in order to obtain multi-modal transport. At the end of each of these seminars, students and professionals can interact during a networking event. What is more, the 'Ecorace-Challenge' also wants to encourage entrepreneurship and innovation within this sector. Therefore, the teams need to write a business plan to elaborate on the possible scalability of their project to the industry. Herein the knowledge and expertise gained during the seminars and meetings with professionals can be used.

During the weekend of the race, the self-designed vessels will be inspected to check compliance with the regulations. In parallel, the sustainable and innovative aspects of each design are inspected and assessed based on level of difficulty, progression and innovation.

Because the technical regulations of the competition allow a wide variety of energy sources, vessels using hydrogen (fuel cell or combustion), bio-fuels or solar energy can be expected. Next, during the navigation challenges in different disciplines, several aspects of the vessel will be investigated and scored, like speed, manoeuvring with a load of 1 ton and passing through a lock.

The goal of this challenging project is to make people (especially students) aware of the opportunities and importance of this transport mode and to show that the inland waterway sector is much more than the old-fashioned character. Based on the potential of the competition, it can be concluded that the Ecorace-Challenge, a boat race for technical students in terms of sustainability and environmental friendliness, is a good project to make (young) people aware of the transport mode of the future: inland waterway transport.

2. Inland Waterway Navigation, an interesting and sustainable industry

Inland waterways still play an important role in nowadays transportation, especially in western Europe where a dense network of waterways can be found. The Belgian waterway network is regionalized and is hereby divided into the following categories: the Flemish Region, the Walloon Region, the Brussels Capital Region and the maritime accesses. In the Flemish Region, the waterway network is managed by two waterway managers: "Waterwegen en Zeekanaal NV" and "NV De scheepvaart". "Waterwegen en Zeekanaal NV" manages the central and western part of the Flemish waterway network. "NV De Scheepvaart" manages the most important waterways in the province of Antwerp and Limburg. The Belgian waterway network is an important passage to waterways in other West-European countries like The Netherlands, Germany, France, Luxembourg and Austria. Besides, the port of Antwerp is the second largest port of Europe and has an interesting strategic location, right in the middle of crossroads of major European trade routes.

This dense network results in a lot of possibilities for the versatile use of the waterways within different transport modes. Flanders has several channels that reach deep into the inland. It is therefore logical that the combination of water and road or rail transport has strong assets. Sea and inland waterway transport in combination with modal shift will be the transport mode of the future and will play an important role in reducing the pressure on the roads in the future.

Water transportation is one of the oldest means of transport. In consideration of Europe and Belgium there is ample availability of water so transportation can be done throughout the year. As water transport is done by rivers, canals, inland and sea which are the natural ways, cost efficient, safe and environmental friendly, it can be seen that this transport mode has a lot of potential compared to other modes of transportation.

The use of ships is very sustainable and environmentally friendly compared to road, air and rail transport. The energy consumed to cover a certain distance is much more efficient. For example, a ship of 1350 tons consumes four to seven times less fuel per kilometre than trucks. Moreover, with 5 litres of fuel a ship can transport a ton of goods for 500 km, whereas a train can only travel 333 km, a truck only 100 km and an airplane hardly 6,6 km (see Figure 1) (Promotie Binnenvaart Vlaanderen, 2008). This benefit includes also less polluting emissions into the air. A long-term trend is the decline in the number of inland ships, accompanied by an increase in the load capacity which make the waterways even more attractive.

Figure 2: Number of kilometres per transport mode with 5 litres of fuel

2.1 Challenges for Flanders inland waterways

Improvements in terms of environmental friendliness and sustainability can still be made for inland waterway transport, especially the emissions of particular mater and nitric oxide. The lifetime of a cargo ship can easily reach over 20 years. In many cases the type of drive train has been kept original, but technologies has improved and nowadays available technologies are more efficient and cleaner. The EU already announced some measures and regulations to reduce the emissions of nitric oxide by 2020. Therefor R&D and innovation in the inland waterways sector has to be encouraged.

Moreover, as a result of the outdated image and infrastructure of this business, people don't see the opportunities and benefits. Today as never before there is a growing need for integrating environmentally sound choices into supply-chain management research and practice (Cucchiella et al, 2010). It's not only an interesting, economic and environmental way of transport but it can also be an interesting alternative to release the pressure on our highways when we manage to combine water, rail and road transport. Therefore people need to be made aware of the need of sustainability and environmental friendliness in the logistics and transport sector.

3. The Ecorace-Challenge

To encourage young people to interact with the businesses around inland waterway transport, Waterwegen en Zeekanaal NV and KU Leuven - GROUP T launched a new competition for technical bachelor and master students. The aim of the "Ecorace-Challenge" is to strengthen the interaction between Education, Research and Industry and to stimulate the business climate within the sector, so new developments and initiatives can be launched.

The teams are challenged to start their own business as ship builders. They have to design and build a small vessel, making use of sustainable technologies. Moreover, the vessel should be scalable to the smallest type of ship that is currently being used for inland waterway navigation. For the realization of their vessel, the teams needs to gain their own financial and material recourses.

During the project time, teams need to brief periodically the organization about their progress. There are also some deadlines related to design reports, a FMEA study and a business plan.

During this year teams will also be invited to different networking events by companies and organisations within the sector. Consequentially students can hopefully benefit from their new contacts and insights in the sector. Occasionally they will be asked on events to talk about their experience with the Ecorace-Challenge and their progression. At the end of the competition they will have to present their business plan to a jury of professionals active in

the inland waterway sector and/or research institutes. It is of big importance that teams use the information and the insights of the network events for their defence.

Figure 3: Website of the Ecorace-Challenge

3.1 Teams

It is the first time this competition will be held. Therefore the organizing committee opted to only allow a small amount of teams to participate within the pilot edition of the race. Because the competition is funded through Flanders industry, only Flemish Universities where able to apply to the event. The competition, held from 9 till 11 May 2014, will host four universities which will compete against each other: University of Antwerp, Hasselt University, KU Leuven – GROUP T and Antwerp Maritime Academy. The event will take place at the marina nearby the lovely city of Ieper.

Figure 4: Map of Belgium showing the participating Universities

3.2 Technical Regulations.

Within the technical side of the competition, each team will build a vessel capable of sailing more than 30 km. They start from line diagrams of a barge which is scaled down to a boat with a length of 6 m. The teams are free to produce their own hull in any material. They can opt for standard glass-fibre composite solutions or look for more sustainable options like for example bio-composites. Before the teams are allowed to sail the vessel during the competition all team needs to indicate by calculation that the hull is strong enough. This matter is very important when you know there will be always one or two persons on board with the possibility of an additional load of one ton. Additionally, the vessel will be inspected in detail during the official scrutineering.

To inform all teams of the different technical restrictions a document of about 20 pages was written. The main purpose of this document is to assure that all vessels comply with a high standard of safety. Besides, it also allows a fair competition between the teams.

The design rules for the propulsion system are relatively open, but green design is encouraged, since it is an important sub-topic to sustainable transportation and environmental awareness (Srivastava, 2007). The regulations allow different types of fuels, going from solar panels, hydrogen, CNG, petrol to bio-fuels. Only wind, human and animal power are not allowed. This can be used for direct propulsion or for on-board energy generation which may be stored in an energy storage system of maximum 5 kWh.

Figure 5: Hull of the vessel of the KU Leuven – GROUP T team

Teams are only allowed to make some design changes within the last meter of the 6 meter long hull to optimize their propulsion system. The standard hull speed is determined at about 12 km/h, but can still be improved. The maximum allowed output power for the propulsion system is 8 kW or 6 hp. The topology of propellers is open, so one or more propellers are allowed to improve manoeuvrability. Teams need to take into account the scalability of their drive train, so it is more or less possible to apply the same system in an up-scaled barge. This will be of importance for the decisiveness of their business plan.

3.3 Overall regulations

The competition doesn't consist of only one race. Multiple challenges are defined to make sure the boats can be used in versatile situations, so it is agile, sustainable, fast and reliable. Additional to the challenge a more management-oriented part is introduced where teams show how their organization as ship builders works. Each challenge and assignment will be scored separately with points. At the end the team with the highest overall score will be awarded as the winner of the "Ecorace-Challenge". The scoring of the different challenges and assignments can be found in table 1.

Category	**Max. points**
Design report	100
FMEA	50
Electrical scheme report	100
Sprint	50
Forward-stop-backward	50
Slalom	50
Endurance	300
Business plan and presentation	100
TOTAL	**800**

Table 1: Scoring overview of assignments and challenges

3.4 Challenges

The competition exist out of four different practical tests on the water: Sprint, Forward-Stop-Backward, Slalom and Endurance, whereby each team tries to set a best time for each challenge. For the Sprint, Forward-Stop-Backward and Slalom challenges speed is mainly important, while energy efficiency plays an important role in the Endurance challenge. The winning team gains the maximum point of the challenge where the points of the other teams are calculated by a formula taking into account the time difference with the fastest team.

3.4.1 Sprint

Within this challenge, teams need to cover a distance of 200 meters as quick as possible, starting from standstill. Teams may change propellers if needed. The goal is to accelerate as quick as possible.

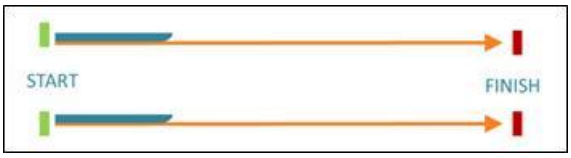

Figure 6: Illustration of the Sprint Challenge

3.4.2 Forward-Stop-Backward

Having a good manoeuvrable ship for inland waterway navigation is essential. During the challenge the shipper need to sail 100 meters where after he tries to come to a standstill in a marked area. Next, he will need to navigate 100 meters backward. This challenge will be scored on time, but as well by a jury on its smoothness.

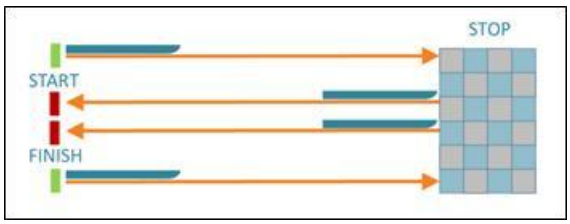

Figure 7: Illustration of the Forward-Stop-Backward Challenge

3.4.3 Slalom

For the Slalom challenge the vessel needs to follow a track, indicated by buoys, of 250 meters. This test will show how stable and agile the ship is. This challenge will be scored similar to the Forward-Stop-Backward.

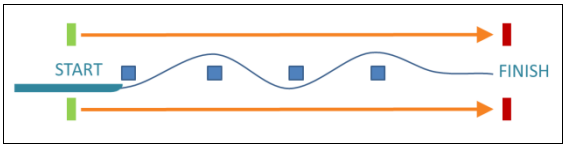

Figure 8: Illustration of the Slalom Challenge.

3.4.4 Endurance

The flagship of all the challenges is the Endurance: a 26 km long trajectory on the Ieperlee canal in Flanders. During this part of the race teams will pass a lock on their way two times. The first half of the trajectory, teams will sail without any ballast. The second half, teams need to take an extra ballast of a ton on board of the vessel, as shown in figure below. Vessels on solar energy don't need to take an extra ballast of a ton, because this will not be feasible for them. This adjustment will be inserted in the key formula to calculate the points for this challenge.

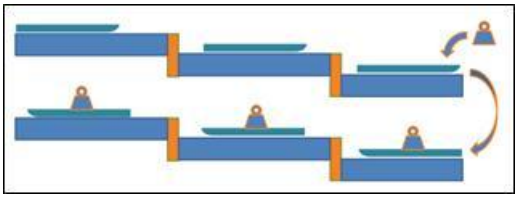

Figure 9: Illustration of the Endurance Challenge

In contrast to the other challenges, not only time will be taken into account but also efficiency. Each vessel power consumption will be monitored. The key formula will take both parameters into account to determine the points gained during this challenge.

Figure 10: Relation efficiency vs speed

3.5 Award ceremony

At the end of the competition there will be 3 different awards. A 1st for the overall winner, i.e. the team with the highest total score. A 2nd for the team with the most efficient vessel, i.e. the team that completed the Endurance test in the most efficient way. A 3rd for the team with the most innovative vessel, i.e. the team that most excels in the use of new sustainable technologies.

4. Conclusion/Summary

As result of the dense network of rivers and canals in Flanders, inland waterway transport still has a lot of potential to grow. Unfortunately, throughout the years the image of the sector has become outdated and less attractive. Now it is the time to reinvent the business and to show the public the potential and its benefits. Inland waterway transportation can be seen as an economical and sustainable alternative to road and rail transport.

Therefore this paper presented an interesting initiative "Ecorace-Challenge" to reduce the gap between Education, Research and the Inland Waterway Navigation, especially by young people. The initiative is a competition for bachelor and master students with interest in maritime industry. The Ecorace-Challenge covers both a technical side, where each team needs to build a 6 m long vessel, and a more management-oriented side, where the team needs to act as real ship builders and present their business plan to a jury of experts. For the proper conduct of the competition, guidelines and regulations were defined which each team needs to comply with.

From 9 till 11 May 2014 all teams will come together in Ieper where the challenges of the first Ecorace-Challenge will take place. This public event shall be organised in close collaboration with lots of support of the maritime sectors and related companies and organisations.

5. Acknowledgement

We would like to thank all the partners involved with the "W&Z Ecorace-Challenge", for their participation and collaboration during the competition.

6. References

Bhoomkar, N., Ceuppens, N., 2013, Research of the Inland Waterway System in Belgium: an investigation of the current and future situation.

Cucchiella, F., D'Adamo, I., Gastaldi, M., 2010, Green Supply Chain and Firm Performance, pre-prints of the Sixteenth International Wortking Seminar on Production Economics, Volume 1, pp.101-112.

European Commission, 2009, "A sustainable future for transport", www.ec.europa.eu/transport/media/publications/doc/2009_future_of_transport_en.pdf

Macharis, C., van Lier, T., Pekin, E., Verbeke, A., 2011, Intermodaal binnenvaartvervoer: economische en ecologische aspecten van het intermodaal binnenvaartvervoer in Vlaanderen, VUBPRESS, Brussel.

Promotie Binnenvaart Vlaanderen, 2013, "Binnenvaart", www.binnenvaart.be

Srivastava, S.K., 2007, Green Supply-Chain Management: A State-of-the-Art Literature Review, International Journal of Management Reviews, Vol. 9(1), pp. 53-80.

Sys, C., Vanelslander, T., 2011, Future Challenges for Inland Navigation. Brussel: UPA.

Waterwegen & Zeekanaal NV, 2013, "W&Z Ecorace Challenge", www.ecorace-challenge.be